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U. S. FOREST SERVICE
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Research Note
FOREST AND RANGE EXPERIMENT STATION · U.S. DEPARTMENT OF AGRICULTURE · PORTLAND, OREGON

PNW-24

May 1965

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1965
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CORRECTION OF AVERAGE YARDING DISTANCE FACTOR FOR CIRCULAR SETTINGS

by

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INTRODUCTION

In performing cost analysis of logging operations, a factor is commonly used to obtain the average yarding distance. The geometry which the setting most closely approximates (rectangular, square, triangular, or circular) determines the factor to be used. The distance from the landing to the external edge of the setting is multiplied by this factor to obtain an average yarding distance for the setting.

This note is concerned with settings which are roughly circles, with the landing in the center, or those which approximate circular sectors (pie-shaped areas), with the landing at the apex. The factor given by Matthews (p. 82)[1] and Bureau of Land Management (Table 4 (9331.22B))[2] is 0.707, but the analysis below shows that the factor should be 2/3 (0.667). A brief review of the literature has indicated that the 0.707 factor is in common usage, and no source could be found giving the 2/3 factor.

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[1] Matthews, Donald Maxwell. Cost control in the logging industry. 374 pp., illus. New York and London: McGraw-Hill Book Co., Inc. 1942.

[2] U.S. Department of Interior Bureau of Land Management. Logging costs; schedule 14 (9331.2). 1964.

ANALYSIS

The average yarding distance ($\bar{y}$) is equal to the total yarding distance (Y) for a particular setting divided by the total number of turns (T):

$$\bar{y} = \frac{Y}{T} \tag{1}$$

If we assume that the logs are evenly distributed over the setting (which is never the case but which is quite often close enough to allow the analysis), then the number of turns for a small area of the setting is the same as for any other small area of the same size in the setting. The total number of turns (T) equals the total setting area (A) multiplied by the turn density or log density (D):

$$T = AD \tag{2}$$

Now, consider a small area (ΔA) of the setting for which the yarding distance is constant. The total yarding distance for this small area is equal to the log density times the area (which is the number of turns in the small area) times the yarding distance (y). And for the entire setting, the total yarding distance is obtained by summing the distances for all areas:

$$Y = \Delta A_1 y_1 D + \Delta A_2 y_2 D + \Delta A_3 y_3 D + \ldots. \tag{3}$$

In terms of integral calculus, this becomes,

$$Y = \int_A DydA \tag{4}$$

and, in general terms,

$$\bar{y} = \frac{\int_A ydA}{A} \tag{5}$$

this equation holds for any shape setting.

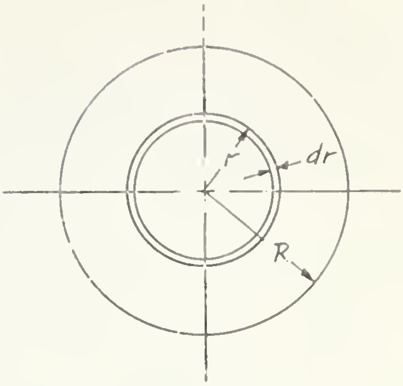
For a circular setting of radius R, using polar coordinates,

$$dA = 2\pi r dr$$

$$y = r$$

$$A = \pi R^2$$

$$\int_A y dA = \int_0^R 2\pi r^2 dr = \frac{2}{3}\pi R^3 \qquad (6)$$



and

$$\bar{y} = \frac{\frac{2}{3}\pi R^3}{\pi R^2} = \frac{2}{3}R \qquad (7)$$

which shows that the average yarding distance is 2/3 times the external distance. A similar analysis will show that the factor is the same for a setting in the shape of a circular sector.

PERCENT ERROR

The bias introduced by using a factor of 0.707 instead of the correct factor of 2/3 is plus 6 percent. Under most engineering disciplines, a bias of this magnitude would be intolerable, but in view of the other quantities which go into a logging cost analysis, it is probable that a 6-percent error in the average yarding distance factor will have little effect on the overall accuracy of logging cost estimates. However, it is recommended that the correct factor of 2/3 (0.667) be used in the future.